

A study on the Caryopses morphology of the grass genus *Eragrostis* in India

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भारत में तृण वंश इराग्रोसटिस के केरियोप्सेस आकारिकी पर अध्ययन

सी.पी. विवेक, जी.वी.एस. मूर्ती, जी. ज्ञानसेकरण, के.ए.ए. कबीर एवं वी.जे. नायर

सारांश

प्रकाश सूक्ष्मदर्शी एवं स्कैनिंग इलेक्ट्रॉन सूक्ष्मदर्शी द्वारा भारतीय इराग्रोसटिस वॉल्फ के केरियोप्सेस आकारिकी पर किया गया अध्ययन प्रस्तुत है। अब तक कुल 44 जातियों पर अध्ययन किया जा चुका है। अनुप्रस्थ काट में आकार, विस्तार, रंग, प्रारूप पर जोर दिया गया है जिसमें उनकी आकृति अंडाकार, उपअंडाकार, दीर्घवृताकार, कोणीय दीर्घाकार या अंत में स्थूल, गोलाकार, उपगोलाकार, प्रिज्म की तरह कोणीय या पार्श्विक प्रणाली सहित या अपार्श्विक प्रणाली में भिन्नता दर्शाती है। अनुप्रस्थ काट में इनकी आकृति वृत्तीय, हृदयाकार, अंडाकार, उपअंडाकार इत्यादि में परिवर्तित होती रहती है। सतही कोशिका शिराविन्यास आमतौर पर संकीर्ण एवं आयाताकार होते हैं।

ABSTRACT

A study on the caryopses morphology of Indian *Eragrostis* Wolf using Light Microscope and Scanning Electron Microscope is presented. A total of 44 species have been studied. Emphasis has been given to their shape, dimensions, colour, outline in cross section and surface features. The shape varies from ovoid, obovoid, ellipsoid, oblong with truncate or obtuse ends, globose, subglobose, prism like and angled with or without lateral grooves. In cross section the shape varies from circular, cordate, obcordate, ovate and obovate etc. Surface cell reticulations are mostly narrow and rectangular.

Keywords: Caryopses, Morphology, *Eragrostis*, Poaceae, India

INTRODUCTION

The morphology of caryopses in the grass family Poaceae is an important character for the classification of different species coming under it. According to Heywood & Davis (1963), seed characters are reliable and constant within a taxon. It can be used to infer hypothetical relationships among the grasses (Colbry 1957; Terrell & Peterson 1993; Peterson & al., 2007). A number of papers have already been published in other countries on the caryopses

morphology and its significance in classification. Many taxonomic treatments of the subfamily Chloridoideae have included this as an important tool in grouping species and especially so in *Eragrostis*, the largest genus of the said subfamily. Lazarides (1997), Peterson & Sánchez Vega (2007), Giraldo-Canas & al. (2012) etc. have included the caryopses morphology of *Eragrostis* as this is an important character for species delimitation. Boe-chat & Longhi-Wagner (2003) grouped 49 of the 53 species of Brazilian *Eragrostis* into 6 groups based on the

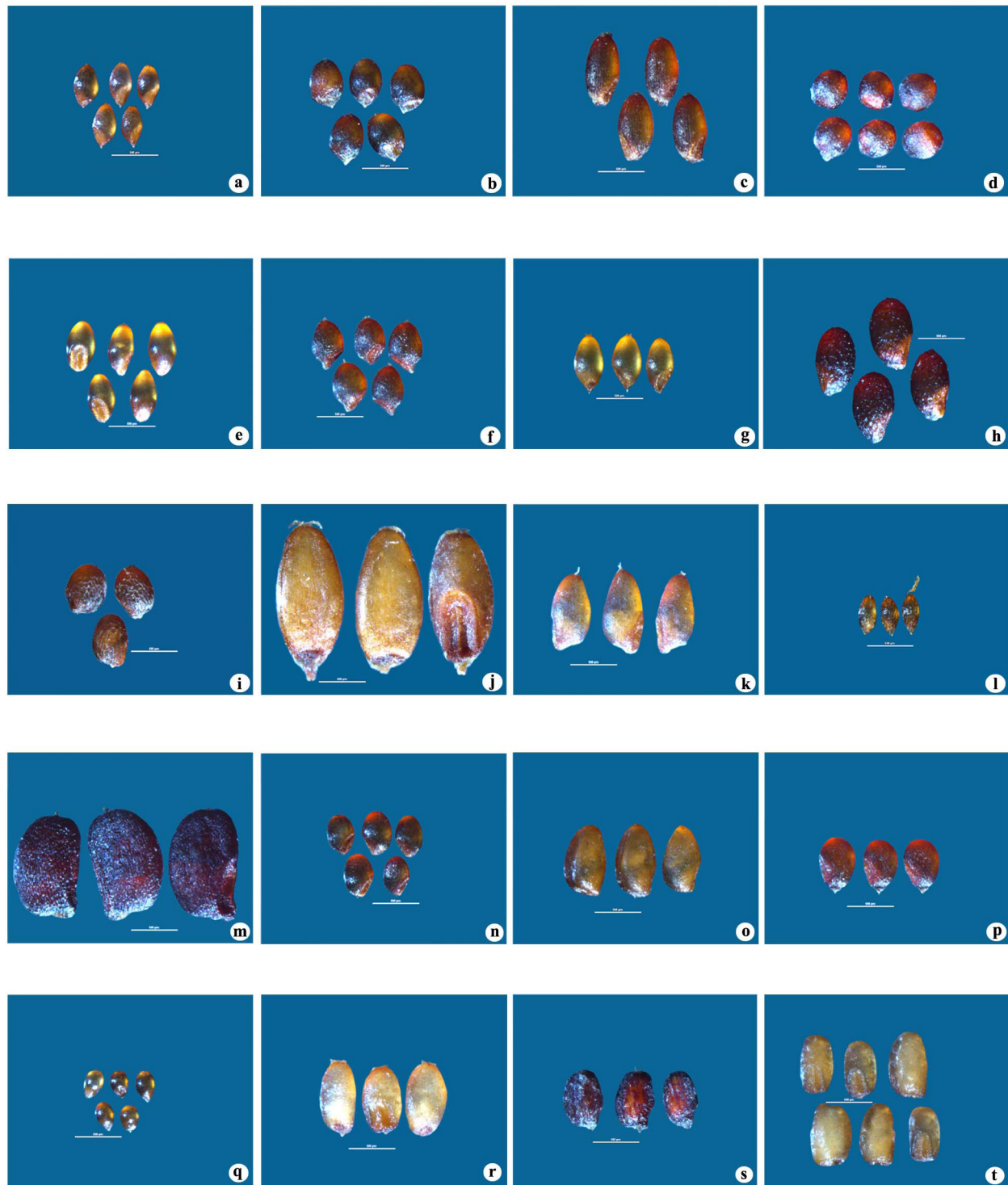


Plate -1: Nikon SMZ 1500 microscopic images of caryopses of: **a.** *Eragrostis amabilis*; **b.** *E. aspera*; **c.** *E. atrovirens*; **d.** *E. cilianensis*; **e.** *E. ciliaris*; **f.** *E. ciliata*; **g.** *E. coarctata*; **h.** *E. collinensis*; **i.** *E. cumingii*; **j.** *E. curvula*; **k.** *E. deccanensis*; **l.** *E. diarrhena*; **m.** *E. ferruginea*; **n.** *E. gangetica*; **o.** *E. henryi*; **p.** *E. jainii*; **q.** *E. japonica*; **r.** *E. lehmanniana*; **s.** *E. macilentia*; **t.** *E. maderaspatana*.

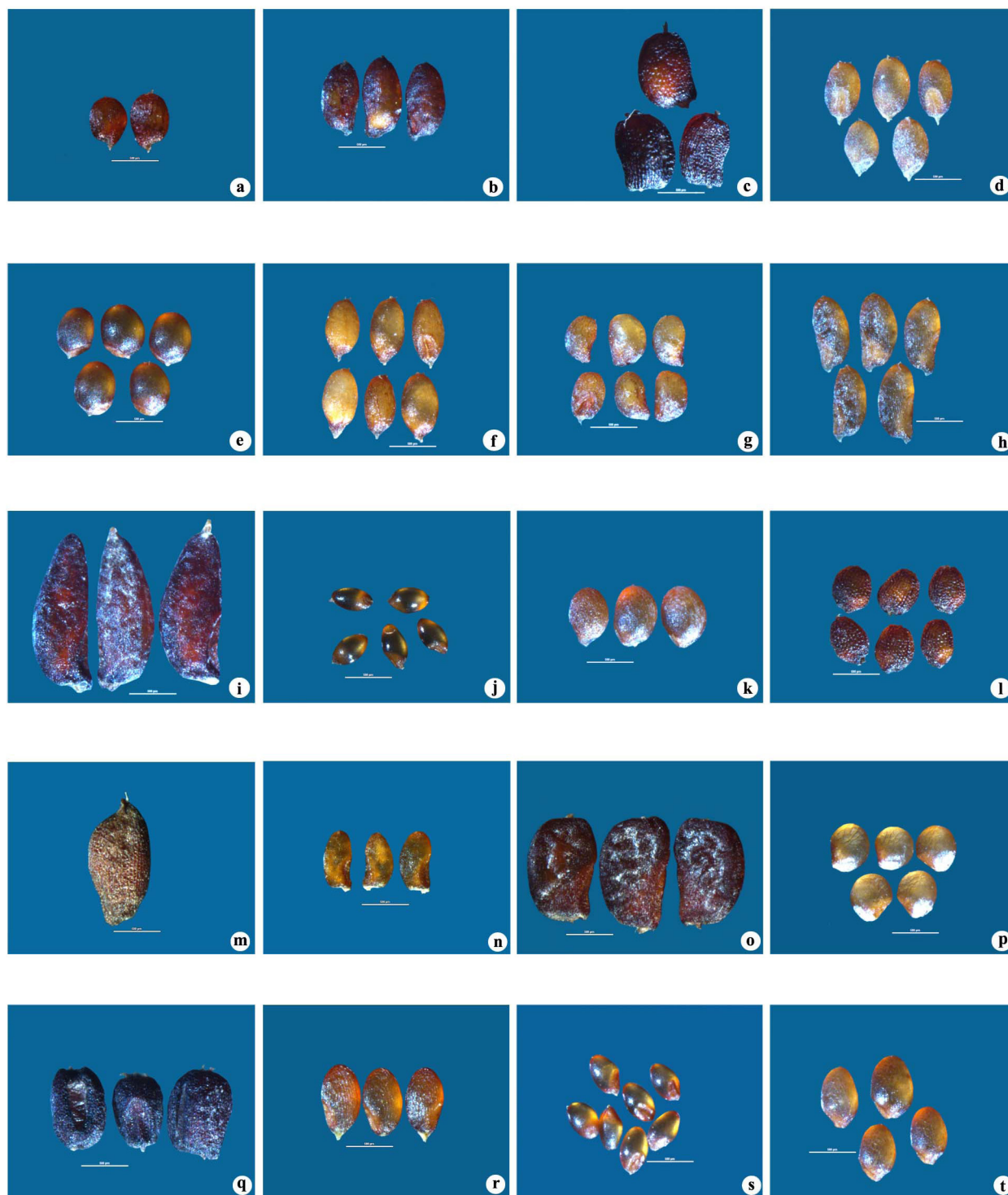


Plate -2: Nikon SMZ 1500 microscopic images of caryopses of: **a.** *E. minor*; **b.** *E. multicaulis*; **c.** *E. nigra*; **d.** *E. nilgiriensis*; **e.** *E. nutans*; **f.** *E. pappiana*; **g.** *E. papposa*; **h.** *E. pilosa*; **i.** *E. plana*; **j.** *E. riparia*; **k.** *E. santapau*; **l.** *E. schweinfurthii*; **m.** *E. superba*; **n.** *E. tef*; **o.** *E. tenuifolia*; **p.** *E. tremula*; **q.** *E. trichodes*; **r.** *E. unioloides*; **s.** *E. viscosa*; **t.** *E. zeylanica*.

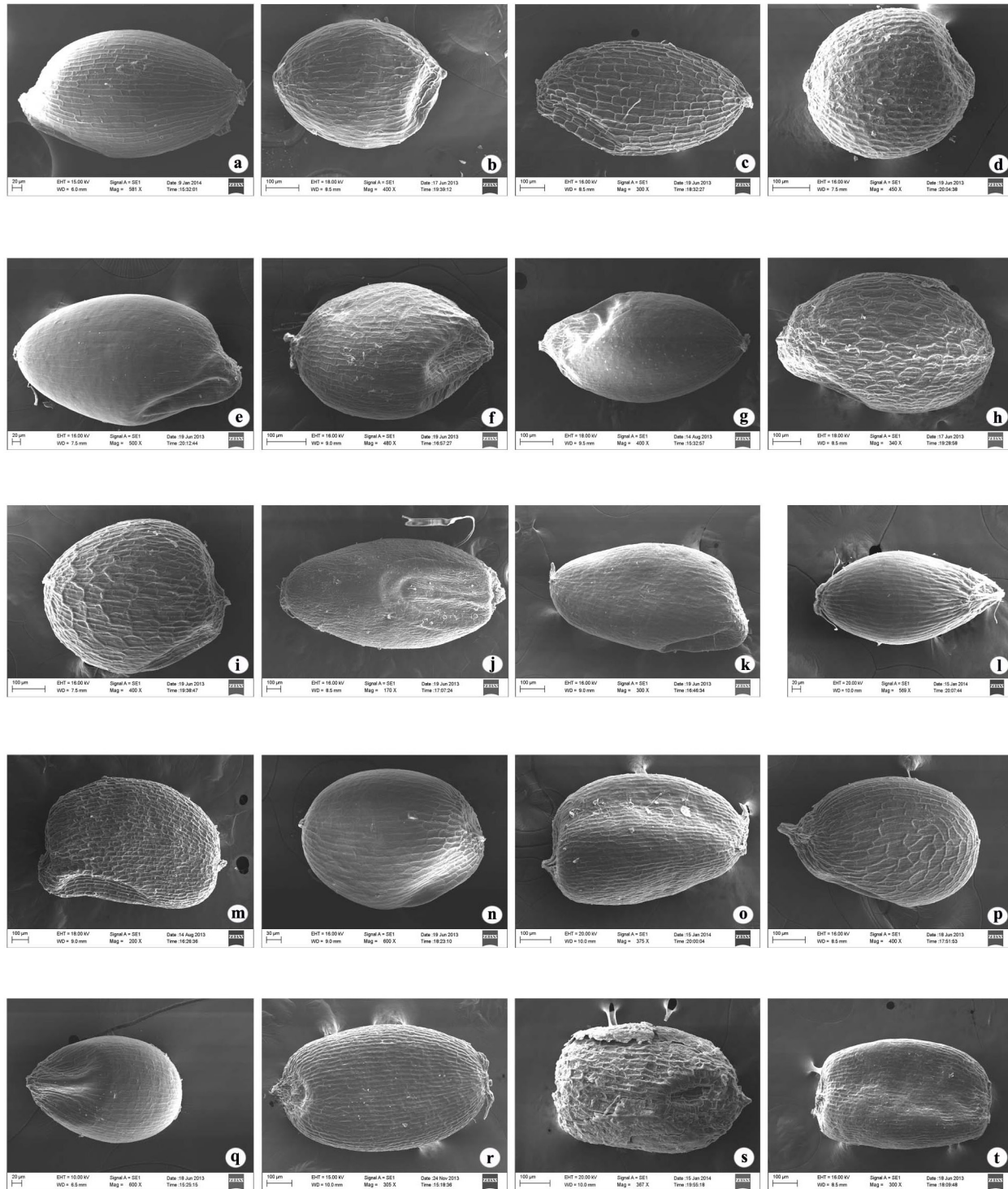


Plate -3: SEM features of caryopses of : **a.** *Eragrostis amabilis*; **b.** *E. aspera*; **c.** *E. atrovirens*; **d.** *E. cilianensis*; **e.** *E. ciliaris*; **f.** *E. ciliata*; **g.** *E. coarctata*; **h.** *E. collinensis*; **i.** *E. cumingii*; **j.** *E. curvula*; **k.** *E. deccanensis*; **l.** *E. diarrhena*; **m.** *E. ferruginea*; **n.** *E. gangetica*; **o.** *E. henryi*; **p.** *E. jainii*; **q.** *E. japonica*; **r.** *E. lehmanniana*; **s.** *E. macilentia*; **t.** *E. maderaspatana*.

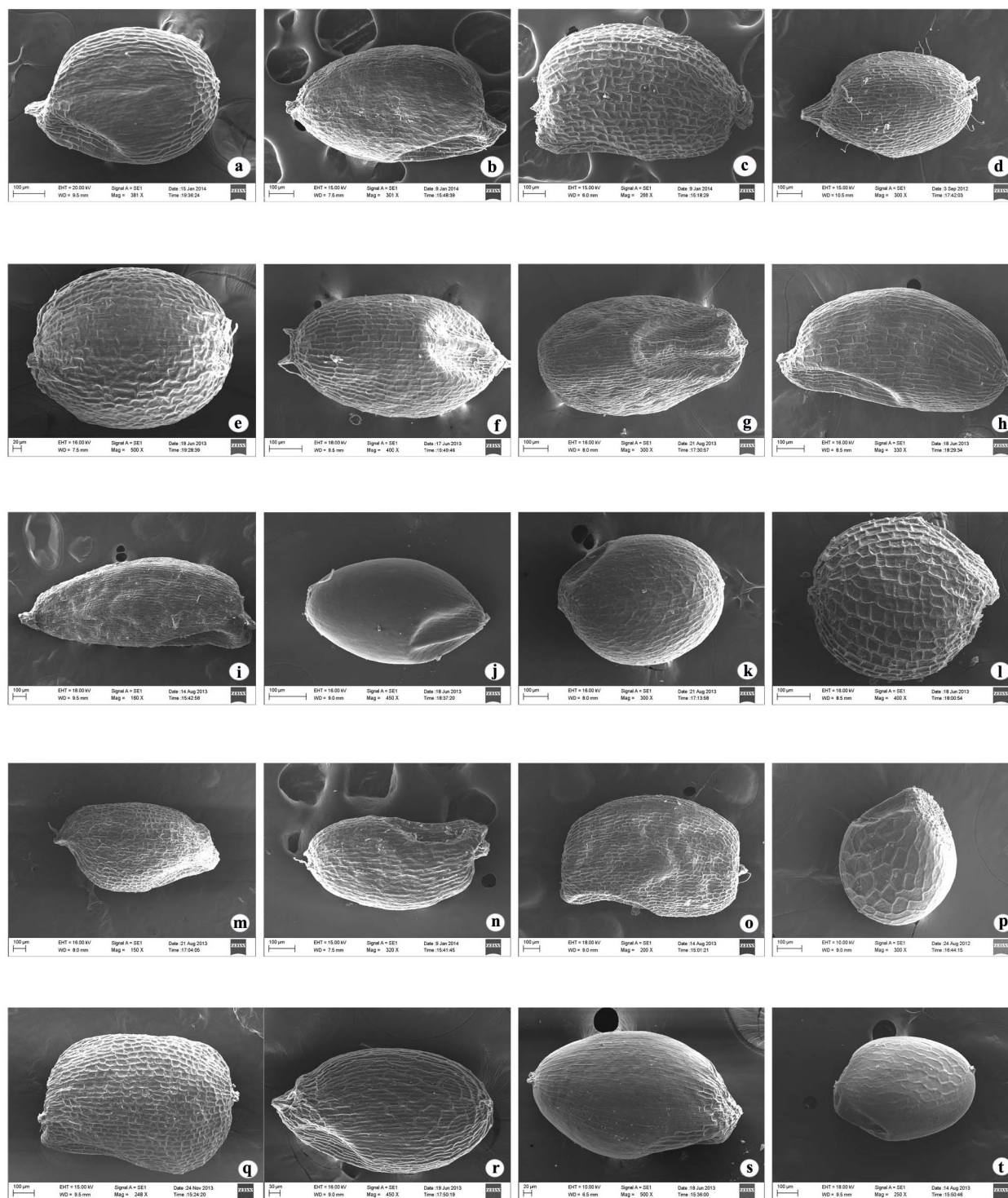


Plate -4: SEM features of caryopses of **a.** *E. minor*; **b.** *E. multicaulis*; **c.** *E. nigra*; **d.** *E. nilgiriensis*; **e.** *E. nutans*; **f.** *E. pappiana*; **g.** *E. papposa*; **h.** *E. pilosa*; **i.** *E. plana*; **j.** *E. riparia*; **k.** *E. santapau*; **l.** *E. schweinfurthii*; **m.** *E. superba*; **n.** *E. tef*; **o.** *E. tenuifolia*; **p.** *E. tremula*; **q.** *E. trichodes*; **r.** *E. unioides*; **s.** *E. viscosa*; **t.** *E. zeylanica*.

Table 1: Morphological features of caryopses of *Eragrostis* Wolf in India

Name of species	Shape/in cross section	Length (in mm)	Surface cell ornamentations	Colour
* <i>E. amabilis</i> (L.) Wight & Arn.	Ovoid to ellipsoid/ Circular	0.3 – 0.5	Medianly reticulate/ Rectangular thin walled narrow cells	Light brown
* <i>E. aspera</i> (Jacq.) Nees	Ovoid-subglobose/ Circular	0.4 – 0.5	Medianly reticulate/ Rectangular thin walled narrow cells	Deep brown
* <i>E. atrovirens</i> (Desf.) Trin. ex Steud.	Ellipsoid to oblong/ Circular	0.6 – 0.7	Prominently reticulate/ Rectangular thin walled narrow cells	Deep brown
* <i>E. burmanica</i> Bor	Ellipsoid; ventrally grooved/Cordate	0.6 – 0.75	-	-
* <i>E. cilianensis</i> (All.) Vignolo Lut. ex Janch.	Globose to orbicular/ Circular	c. 0.4	Prominently reticulate/ Iso-diametric thick walled narrow cells	Reddish brown
* <i>E. ciliaris</i> (L.) R. Br.	Ovoid to ellipsoid/ Circular	0.3 – 0.5	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. ciliata</i> (Roxb.) Nees	Ovoid to ellipsoid/ Circular	0.4 – 0.5	Medianly reticulate/ Rectangular thin walled narrow cells	Deep brown
* <i>E. coarctata</i> Stapf	Ovoid to ellipsoid/ Circular	0.4 – 0.5	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Yellowish brown
# <i>E. collinensis</i> Vivek, G.V.S. Murthy & V.J. Nair	Obovoid to ellipsoid; laterally compressed/Ovate	c. 0.7	Prominently reticulate/ Iso-diametric thick walled broader cells	Reddish brown
* <i>E. cumingii</i> Steud.	Ovoid to globose; narrowly compressed laterally/Ovate	c. 0.5	Prominently reticulate/ Iso-diametric thick walled broader cells	Deep brown
+ <i>E. curvula</i> (Schrud.) Nees	Ellipsoid to prismatic; ventrally grooved/Cordate	0.8 – 1	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Yellowish brown
# <i>E. deccanensis</i> Bor	Ovoid to ellipsoid; narrowly compressed laterally/Ovate	0.4 – 0.9	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. diarrhena</i> (Schultes) Steud	Obovoid to ellipsoid/ Circular	0.4 – 0.5	Finely reticulate/ Rectangular thin walled narrow cells	Light brown
* <i>E. diplachnoides</i> Steud.	Obovoid/Circular	0.2 – 0.25	-	-
* <i>E. ferruginea</i> (Thunb.) P. Beauv.	Rectangular to prismatic; ventrally grooved/Cordate	0.7 – 1.5	Prominently reticulate/ Rectangular thick walled narrow cells	Dark reddish
* <i>E. gangetica</i> (Roxb.) Steud.	Ovoid to ellipsoid; narrowly compressed laterally/Ovate	c. 0.4	Finely reticulate or almost smooth/ Rectangular thick walled narrow cells	Deep brown
* <i>E. henryi</i> Vivek, G.V.S. Murthy & V.J. Nair	Ovoid; ventrally grooved/Cordate	0.5 – 0.6	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. jainii</i> Vivek, G.V.S. Murthy & V.J. Nair	Obovoid; laterally compressed/Ovate	0.4 – 0.5	Prominently reticulate/ Iso-diametric thick walled broader cells	Reddish brown

Name of species	Shape/in cross section	Length (in mm)	Surface cell ornamentations	Colour
* <i>E. japonica</i> (Thunb.) Trin.	Obovoid/ Circular	0.2 – 0.25	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Light brown
⁺ <i>E. lehmanniana</i> Nees	Ellipsoid to ovoid; dorsally grooved/ Cordate	0.6 – 0.8	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. macilenta</i> (A. Rich.) Steud.	Oblong; ventrally grooved/ Cordate	c. 0.5	Prominently reticulate/ Rectangular thick walled narrow cells	Dark reddish
* <i>E. maderaspatana</i> Bor	Oblong to ellipsoid; ventrally grooved/ Cordate	0.5 – 0.8	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. minor</i> Host	Globose to oblong; narrowly flattened ventrally/ Almost circular	0.6 – 0.8	Prominently reticulate/ Rectangular thick walled narrow cells	Reddish brown
* <i>E. multicaulis</i> Steud.	Ellipsoid to oblong; laterally compressed/ Ovate	0.5 – 0.8	Finely reticulate/ Rectangular thin walled narrow cells	Reddish brown
* <i>E. nigra</i> Nees ex Steud.	Oblong or quadrangular; ventrally grooved/ Cordate	0.4 – 0.6	Prominently reticulate /Rectangular thick walled narrow cells	Dark reddish
# <i>E. nilgiriensis</i> Vivek, G.V.S. Murthy & V.J. Nair	Ellipsoid to oblong; narrowly flattened ventrally/ Almost circular	0.45 – 0.7	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. nutans</i> (Retz.) Nees ex Wight & Arn.	Ovoid to globose/ Circular	c. 0.3	Prominently reticulate/ Isodiametric thick walled broader cells	Deep brown
* <i>E. pappiana</i> Chiov.	Ovoid to ellipsoid; narrowly flattened ventrally/ Almost circular	0.5 – 1	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. papposa</i> (Duf.) Steud.	Oblong to ellipsoid/ Cordate	0.6 – 1.6	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
* <i>E. pilosa</i> (L.) P. Beauv.	Ellipsoid to oblong; laterally compressed/ Ovate	0.4 – 0.5	Medianly reticulate/ Rectangular thin walled narrow cells	Yellowish brown
⁺ <i>E. plana</i> Nees	Oblong to Prismatic; ventrally grooved/ Cordate	1 – 1.6	Medianly reticulate/ Rectangular thin walled narrow cells	Dark reddish
* <i>E. riparia</i> (Willd.) Nees	Ellipsoid to ovoid/ Circular	c. 0.3	Finely reticulate or almost smooth/ Rectangular thin walled narrow cells	Light brown
* <i>E. rottleri</i> Stapf	Subglobose	c. 0.6	-	-
# <i>E. santapau</i> K.G. Bhat & Nagendran	Subglobose to oblong/ Circular	0.3 – 0.8	Medianly reticulate /Isodiametric thick walled broader cells	Light brown
* <i>E. schweinfurthii</i> Chiov.	Globose to orbicular/ Circular	c. 0.4	Prominently reticulate/ Rectangular thick walled broader cells	Deep brown
* <i>E. subsecunda</i> (Lam.) Four.	Ovoid	c. 0.5 – 1	-	-

Name of species	Shape/in cross section	Length (in mm)	Surface cell ornamentations	Colour
[†] <i>E. superba</i> Peyr.	Ellipsoid; laterally compressed/Ovate	1 – 1.5	Prominently reticulate/ Rectangular thick walled narrow cells	Deep brown
[†] <i>E. tef</i> (Zucc.) Trotter	Ellipsoid; laterally compressed/Ovate	1 – 1.2	Medianly reticulate/ Rectangular thick walled narrow cells	Yellowish brown
[*] <i>E. tenuifolia</i> (A. Rich.) Hochst. ex Steud.	Ellipsoid to oblong; ventrally grooved/ Cordate	c. 1	Prominently reticulate/ Rectangular thick walled narrow cells	Deep reddish
[*] <i>E. tremula</i> Hochst. ex Steud.	Subglobose to orbicular; narrowly compressed laterally/Ovate	0.4 – 0.6	Prominently reticulate/ Isodimetric thick walled broader cells	Yellowish brown
[†] <i>E. trichodes</i> (Nutt.) Wood	Oblong; ventrally grooved/Cordate	0.6 – 1.3	Prominently reticulate/ Rectangular thick walled narrow cells	Dark reddish
[*] <i>E. unioides</i> (Retz.) Nees ex Steud.	Obovoid to ellipsoid; laterally compressed/ Ovate	0.4 – 0.6	Prominently reticulate/ Isodiametric thick walled broader cells	Reddish brown
[*] <i>E. viscosa</i> (Retz.) Trin.	Ovoid to ellipsoid/ Circular	0.4 – 0.5	Finely reticulate or almost smooth/ Longitudinal thin walled narrow cells	Light brown
[*] <i>E. zeylanica</i> Nees & Mey.	Ovoid to subglobose; narrowly compressed laterally/Ovate	0.4 – 0.5	Medianly reticulate/ Isodimetric thick walled broader cells	Light brown

(*Native; [†]Endemic; [†]Naturalized)

caryopses morphology. Peterson & Valdes-Reyna (2005) recognized 4 hypothesized lineage within 26 *Eragrostis* species from north eastern Mexico. In India, the ambiguous descriptions in literature due to the confusion in the identity of 3 closely allied species viz. *E. atrovirens* (Desf.) Trin. ex Steud., *E. gangetica* (Roxb.) Steud. and *E. nutans* (Retz.) Nees ex Wight & Arn. has been resolved mainly by studying its actual differences between the morphology of their caryopses (Vivek & al., 2014).

MATERIALS AND METHODS

In the present study the surface features of the caryopses of 44 Indian species of *Eragrostis* were examined by using Optical Microscope and Scanning Electron Microscope (SEM). The methodology used for these studies are as follows.

Light Microscopy

With the help of optical microscopes Nikon SMZ 1500 and Olympus 01C, 1869 the size, shape and colour of the caryopses were studied. Mature and dried caryopses were manually separated from spikelet and observed under different magnifications. Measurements have been taken

with the help of a scale or a glass slide with a graph sheet pasted on it. The enlarged image of the caryopses with scale of magnification has also been captured by using the computerized microscope, Nikon SMZ 1500.

Cross section of the caryopsis of each species has been taken to observe its exact outer shape. For this the caryopsis was cut horizontally into two halves after soaking it in water. The cut surface was examined under a microscope and a diagrammatic sketch of it was prepared in each case (fig. 1).

SEM

Scanning Electron Microscope (Evo M 18, Carl Zeiss) was used to study the ultra-micro morphology of caryopses. The standard methodology was followed. Mature caryopses surface was cleaned by ethyl alcohol, and 2 – 4 were mounted on a stub coated with a thin film of gold-palladium mixture with the help of Mini Sputter Coater (SC7620, Emitech) and examined under the SEM.

RESULTS AND DISCUSSION

The present study has proved the importance of morphological features of caryopses in the identification of Indian

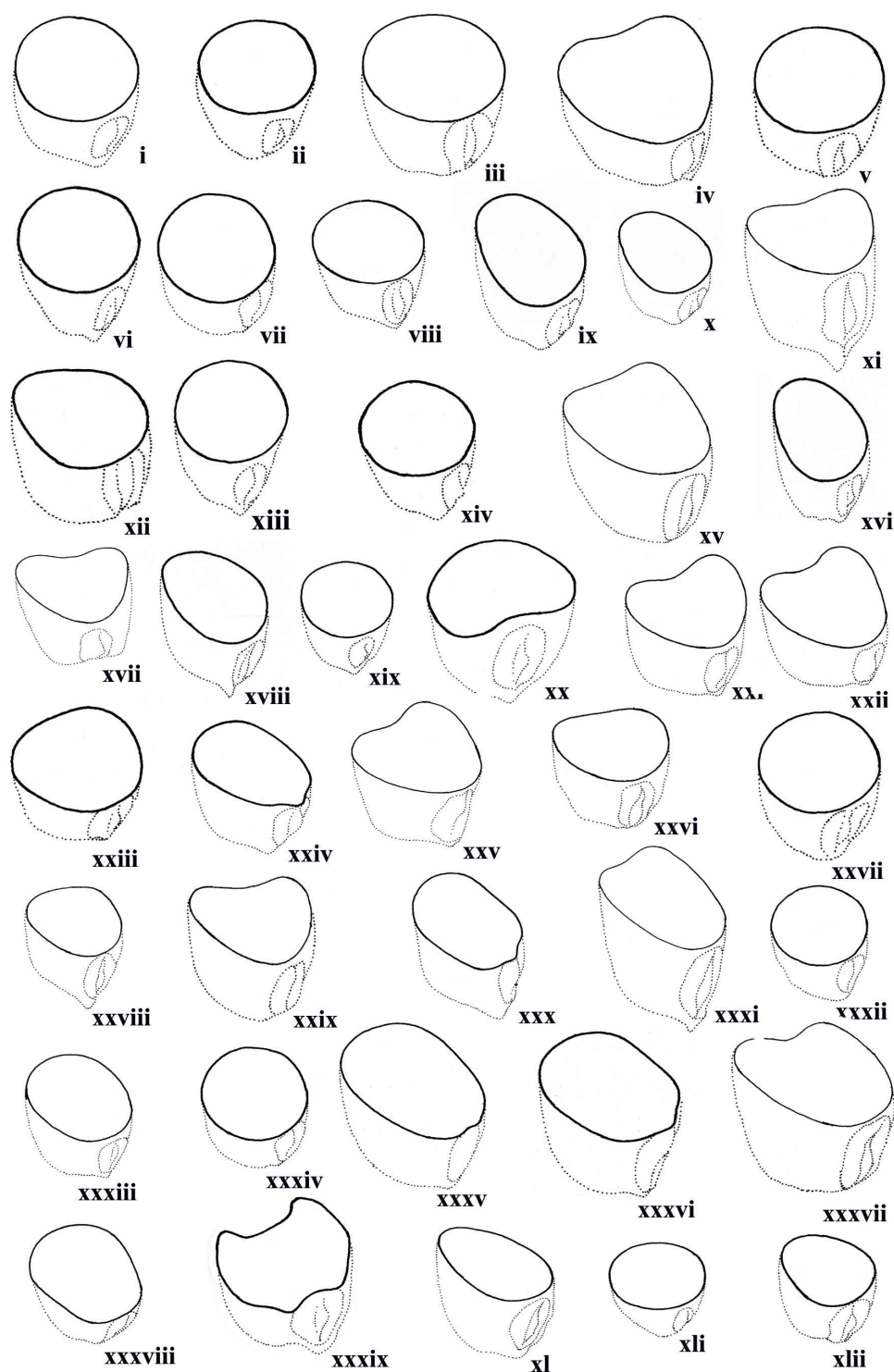


Fig -1: Cross section of caryopses of: **i.** *Eragrostis amabilis*; **ii.** *E. aspera*; **iii.** *E. atrovirens*; **iv.** *E. burmanica*; **v.** *E. cilianensis*; **vi.** *E. ciliaris*; **vii.** *E. ciliata*; **viii.** *E. coarctata*; **ix.** *E. collinsensis*; **x.** *E. cumingii*; **xi.** *E. curvula*; **xii.** *E. deccanensis*; **xiii.** *E. diarrhena*; **xiv.** *E. diplachnoides*; **xv.** *E. ferruginea*; **xvi.** *E. gangetica*; **xvii.** *E. henryi*; **xviii.** *E. jainii*; **xix.** *E. japonica*; **xx.** *E. lehmanniana*; **xxi.** *E. macilentia*; **xxii.** *E. maderaspatana*; **xxiii.** *E. minor*; **xxiv.** *E. multicaulis*; **xxv.** *E. nigra*; **xxvi.** *E. nilgiriensis*; **xxvii.** *E. nutans*; **xxviii.** *E. pappiana*; **xxix.** *E. papposa*; **xxx.** *E. pilosa*; **xxxi.** *E. plana*; **xxxii.** *E. riparia*; **xxxiii.** *E. santapau*; **xxxiv.** *E. schweinfurthii*; **xxxv.** *E. superba*; **xxxvi.** *E. tel*; **xxxvii.** *E. tenuifolia*; **xxxviii.** *E. tremula*; **xxxix.** *E. trichodes*; **xl.** *E. unioides*; **xli.** *E. viscosa*; **xlii.** *E. zeylanica*.

Eragrostis at the intraspecific level if other morphological characters are also added along with it. Caryopses size, shape, colour and nature of ornamentation are the useful characters. Size varies from minute (eg. 0.2 mm in *E. diplachnoides*) up to 1.6 mm long (eg. *E. papposa* & *E. plana*). Shape varies from ovoid, obovoid, ellipsoid, oblong with truncate or obtuse ends. They can also be globose, subglobose, prism like, angled etc. (plates 1,2,3 & 4). They are always longer than broader. In cross sections also they exhibit diverse patterns (Fig. 1). Of the 44 species studied, mainly 5 types of outline shapes have been observed in cross section, i.e. circular, cordate, obcordate, ovate and obovate. Majority of them were circular in cross section (eg. *E. amabilis*, *E. ciliaris* etc.). Caryopses of *E. minor*, *E. nilgiriensis* and *E. pappiana* although almost circular in cross section, their ventral side is slightly flattened but not with a ventral groove as in *E. mederaspatana*, *E. nigra* etc. Many are more or less compressed laterally (*E. deccanensis*, *E. unioides* etc.). Table 1 summarises all the above said features of the caryopses of Indian *Eragrostis* including its surface cell ornamentation. The surface is variously reticulate i.e. prominently reticulate in few species (*E. atrovirens*, *E. schweinfurthii* etc.), medianly reticulate in *E. maderaspatana*, *E. nilgiriensis* etc., finely reticulate or almost smooth in *E. ciliaris*, *E. deccanensis* etc. The cells are rectangular (*E. amabilis*) to polygonal (*E. tremula*), narrower or broader. Thickness of the cells also varies among various species viz. thick walled in *E. cilianensis*, *E. unioides* etc., thin walled in *E. amabilis*, *E. deccanensis* etc. + #

CONCLUSIONS

Caryopses of all the 44 species of *Eragrostis* found in India were subjected to the present study. Out of these, 6 species each are endemic or naturalized and the rest are native species. No major differences could be observed in caryopses morphology of these categories. It is observed that majority of them have ovoid and ellipsoid caryopses and the major shape is circular in cross section. Length of the caryopses comes below 1 mm for more than half of the total number of species. The maximum caryopses length goes up to 1.6 mm in *E. papposa* and *E. plana*. Caryopses colour is mostly the variations of brown (yellowish brown to dark reddish brown). Few species have dark

reddish caryopses. The surface cell ornamentations also are much useful while grouping the species and altogether these characters could be used well in the taxonomy of *Eragrostis* in India.

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